Color as a Visual Cue for Pointing Task Performance in Young Children

Elif GÜNEŞ
Atılım University, Faculty of Art, Design and Architecture, Department of Interior Architecture and Environmental Design, Ankara, Turkey.
elif.gunes@atilim.edu.tr

Nilgün OLGUNTÜRK
Bilkent University, Faculty of Art, Design and Architecture, Department of Interior Architecture and Environmental Design, Ankara, Turkey.
onilgun@bilkent.edu.tr

ABSTRACT
This research examines the effect of color on pointing task performances across primary school first graders, aged seven and eight years old in school environments. The children were taken on the experiment route one by one that starts from point X and ends at point Y. The child was first escorted on the route and s/he was passed by gray or different colored boxes according to the experiment sets. Then s/he was asked to lead the researcher to the end point by the same route. When the children finished their route, they were taken outside of the building from the main entrance and they were asked to point out the end point of the route with their fingers. Statistical analyses of the results confirmed that color has a significant effect on the performance of children to accurately show the end point. Color seems to be helping children to visualize their environments and to improve their mental map. Both genders performed equally accurate. By investigating children's spatial abilities in their natural environments, school administrators, architects, interior architects and designers become more aware about providing more legible physical environments to children for improving their spatial competence.

Keywords: Wayfinding, Route knowledge, Pointing task, Color, Children, School environments.

1. INTRODUCTION
Awareness of the space around is an important issue for finding one's way (Golledge, 1999). Finding one's way especially in spacious environments is prime for survival (Spiers and Maguire, 2008) and is a purposive, directed and motivated activity (Golledge, 1999). Wayfinding is an activity that requires complete involvement with the environment and during this involvement, the wayfinders try to understand the setting they are in and with the information they obtained (Passini, 1984). For successful wayfinding, mainly three stages are required: people first need to orient themselves in space -to know where they are (location) and in which direction they are facing (heading) -, second, they need to plan a route with an understanding of a destination and finally they execute the planned route to the destination (Ishikawa et al., 2008, p.74). Wayfinding performance is in relation with route knowledge and pointing task performance.

Route knowledge that is defined as "a sequence of nodes, together with the segment traveled from one node to another, which the central concept of neighborhoods" (Hunt & Waller, 1999, p.22) is an important issue for wayfinding process. People acquire route knowledge in the process of finding a path to a certain goal location, finding way back, finding a short cut and making a detour (Janzen, 2006). People have to remember not only the objects that were passed through but also the places where they made turns and change of directions for finding the same way back. A variety of specific skills, such as mental rotation, perception, and visualization are required to complete route learning task and to form route scene memory (Malinowski & Gillespie, 2001). It can be provided and represented as a set of familiar scenes that can be distinguished from the unfamiliar scenes (Cornell et al., 1996). Children learn about the environment by the order of events along a route and route reversal performance depends upon their memories of those events. Especially for children, events at the beginning and at the end of the tour are more distinctive than events in the middle.

Pointing task that refers to the ability to imagine how one would look from different perspectives is a dimension of spatial orientation. It is important for real-world spatial tasks such as wayfinding or map reading (Malinowski & Gillespie, 2001). In the pointing task, the participants are asked to point a place/object, not visible from the test site. This is a sensitive measure of spatial competence (Lehnung et al., 2003) and it requires a mental representation of a place that translates directly into distance or direction on map (Hunt & Waller, 1999). The task is performed generally using two techniques that are bearing estimations from a stationary position with a compass-like device or the index finger while stretching arm, turning the whole body towards the pointed direction (Lehnung et al., 2001). Pointing is a straightforward method and is advantageous when used with young children.

Pointing accuracy of children was studied by Lehnung et al. (2003) where the participants indicated the direction of prominent landmarks on the school campus, while sitting in their classroom. They found that pointing accuracy was improved with time spent in the environment and with age. 10 years old children outperformed the younger children and boys outperformed girls. Age related spatial orientation performance in children aged 5, 7, and 11 years old with a pointing task was also studied by Lehnung et al. (2001) in a campus building. After taken on a landmark learning tour, children indicated the location of landmarks with a pointing task. They also looked for the difference between two pointing task methods, namely compass like devices and pointing with a finger. No sex differences appeared but a significant effect of age was found. 11 years old needed less trial than 5 and 7 years old, to reach the learning criterion. In addition, children pointing with finger outperformed the children pointing with a compass like device.

Pointing task performance is correlated with route memory task and related with peoples' directional senses (Murakoshi & Kawai, 2000). *Sense of direction* is fundamental for comprehension of spaces. It is related to information taken from landmarks and routes. People with a good sense of direction are better able to look for information like landmarks and to direct their physical actions at intersections on routes. In addition, they are more accurately able to orient their mental representations of landmarks for matching a scene (Cornell et al., 2003). Heth et al. (2002) added that a good sense of direction provide a reliable reference when a person is navigating by path integration. They found that, compared to adults, children showed poorer knowledge of bearings when they were on-route.

2. SENSE OF SPACE BY CHILDREN

Adults develop their sense of space in years. Adults know how to behave in a case of an inaccurate orientation in an environment and they can control their psychology towards feeling lost. A lost person is unable to identify or orient his present location with respect to known locations (Hill, 1998). Getting lost is very frustrating experience especially for people who are trying to reach a specific destination. On the other hand knowing where you are provides feelings of security and safety. However, children's understanding of environments develops in time (Cornell, et al., 1996). They do not have a meta-knowledge that refers to "knowing what you know". They do not know what they do not know and they could get lost (Hill, 1998). Therefore, especially young children have an inner need to be influenced from their environments. They learn by interacting with their environments. Places that provide positive experiences offer opportunities for children to explore, to manipulate, and to be involved (Wilson, 1997). A disorganized environment suggests to children that they are not valued or respected. These kinds of messages affect children's perception of themselves as learners and explorers, their self-esteem and their feelings of competence. Thus, places that are provided to children have a crucial role in their personal and environmental education.

For most young children preschool and primary school are the first public places that they use and come to know instantly (Orr, 1992). At this time, the experience of school starts to be a dominant force in their lives. It is important to analyze the type of environments provided for young children in the school setting because, the nature and quality of schools are influential on how and what these children learn. Therefore, school's physical environment can be a powerful contributor to children's' overall development (Maxwell & Chmielewski, 2008).

Environments are characterized by affordances that have a very important role on children's perception and learning within that environment. Affordance means "the functional qualities of an environment that helps people meet important goals" (Gifford, 2002, p.72). It may be anything that enables it to be used in a particular way by a particular group of people (Lang, 1987). Physical characteristics such as color, landmarks, and layout of the building are examples to affordances that have an important role on students' perception and navigation (Higgins et al., 2005). These environmental design elements affect the visual recognition of children. This process can inform children that they are not on-route by the absence of familiar or expected cues and by noticing something on route that the child is sure that s/he has never seen it before (Cornell & Hill, 2004).

Color is a flexible and powerful design element that guides as a cue in physical environments. It plays an essential role in design and it touches everything (Hard & Sivik, 2001) in every physical and mental condition (Ünal & Akın, 2017). Color is relevant for the perception of space, building form, wayfinding, ambience, and image (Smith, 2003). Read (2003) reports that "color is a useful design element for wayfinding, spatial orientation, and space definition in children's environment" (p.233). According to Thompson (2003) the function of a space is very important when colors are used in school environments. Using combinations of color for creating color code sections in corridors and stairwells of the building helps not only to navigation and traffic flow (Thompson, 2003) but also route learning process of children (Helvacıoğlu & Olguntürk, 2011).

Prior research examined generally the effects of gender, age, familiarity and different methods of assessments on young children pointing task performances. Even though the empirical evidences highlights the importance of color in physical environment and in wayfinding process, possible links between color and pointing task performances have not received any attention in the literature yet. The current study examines the effect of color on young children pointing task performances.

Based on the above discussion, the hypotheses identified for this current study are as follows:

H1: Color has a significant effect on the pointing task performances of young children in a positive way.

H2: Gender has an influence on pointing task performance in a way that boys might outperform girls. as suggested by previous studies that males outperformed females in indicating the direction of the destination (Lawton et al., 1996; Cubukcu & Nasar, 2005).

3. METHODOLOGY

3.1. Participants

The sample group consisted of one hundred children from Ankara University Private High School in Ankara, Turkey. All participants were peer: primary school first graders, aged

seven and eight years old. As the factor of familiarity has a crucial role in the experiment, only the participants who were unfamiliar to the building took the test. The experiment was conducted with three different sample groups for the three different experiment sets (thirteen girls and nineteen boys for experiment set 1; eight girls and sixteen boys for experiment set 2; fourteen girls and twenty boys for experiment set 3).
In order to control the vision deficits, the children were tested for color vision by using Ishihara's Tests for Colour-Blindness (Ishihara, 1975). In addition, they were asked about their vision deficiencies and to wear their corrective equipments if they had minor vision deficiencies. There were no children having vision problems, thus all were permitted to participate the experiments (Helvacıoğlu, 2007).

3.2. Preparation of the Experiment Site

A route from point X (main entrance of the building) to point Y (biology laboratory) was specified in the building for the experiment. Six decision points, where students would make a decision to orient themselves through the major path and floors, were clarified upon that route and six boxes were placed at these decision points before the experiment (see figures 1, 2 and 3). The boxes were in rectangular form and were placed at vertical direction. They were sized 25x60 cm for keeping the proportional values with the height of the seven and eight years old children (123,5 cm. is the average height of the seven and eight years old children) (see figure 4).

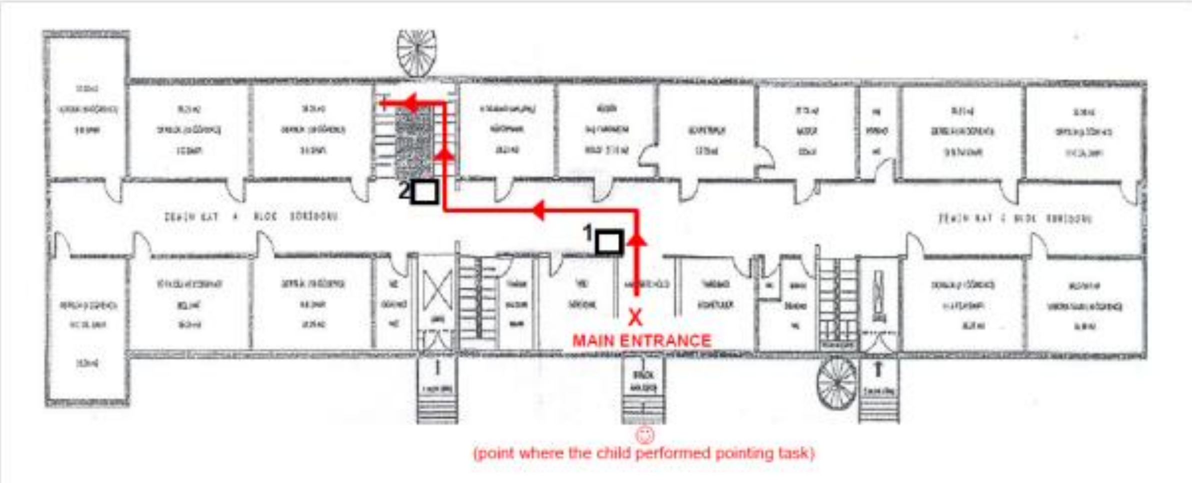

Figure 1. Ground floor plan of the building with starting point X (main entrance) and selected route.

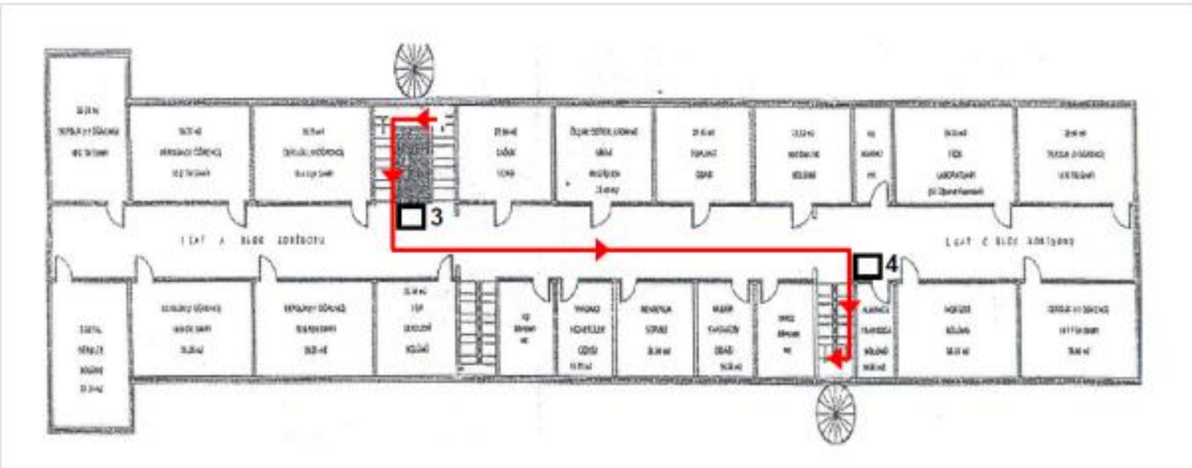

Figure 2. 1st floor plan of the building with the selected route.

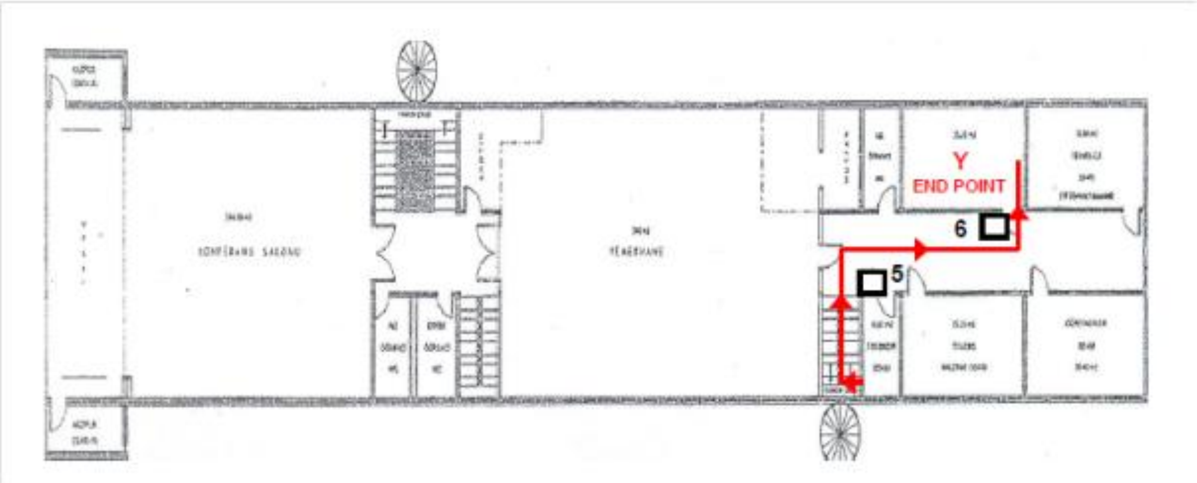

Figure 3. 2nd floor plan of the building with the end point Y (biology laboratory) and the route.

Figure 4.The colored boxes

3.3. Experiment Sets

There were three different experiment sets which differed from each other with their colors and color sequence. In the first set; all of the boxes were colored in gray. In the second and third sets the boxes were colored in yellow, orange, red, purple, blue and green. The difference between the second and the third sets was in the color sequence, in order to control the influence of different color arrangements on pointing accuracies. Natural Colour System (NCS) was used in specification and selection of the colors. The colors of yellow, orange, red, purple, blue and green were tested in the experiment (Helvacıoğlu, 2007). These colors were chosen as being primary and secondary colors of the NCS. After primary colors were selected (yellow, red, blue, green), all equal-distant colors between them (orange, purple, blue-green (turquoise), yellow-green) were selected as secondary colors. However, 'blue-green' (turquoise) and 'yellow-green' were eliminated from the experiment sets as these are not commonly used terms in seven and eight year old children's vocabulary, thus they were relatively difficult to name by children (Dalke et al., 2005).

The arrangement of the colors was done in accordance with the NCS color wheel starting from yellow in clockwise direction. For each floor one hue and its after image complementary hue was used together. Colour sequences of experiment sets were decided according to illumination levels of the decision points (Helvacıoğlu, 2007). Three of the decision points were more illuminated (high illuminance) than the other three. In the second experiment set, colours having short-middle wavelengths (purple, blue and green) were located at low illuminance points (50-100 lux) and colours having long wavelengths (yellow, orange and red) were located at high illuminance points (101-150 lux). In the third set, this systematic procedure was reversed, thus short-middle wavelength colours were located at high illuminance points and long wavelength colours were located at low illuminance points. All corridors had two boxes and two different illumination levels (low and high). The change was achieved by swapping the positions of the pair of boxes in that corridor (see table 1).

Table 1. The color sequences of the experiment sets.

	1st Floor		2nd Floor		3rd Floor	
	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6
Experiment Set 1	Gray	Gray	Gray	Gray	Gray	Gray
Experiment Set 2	Purple	Yellow	Orange	Blue	Green	Red
Experiment Set 3	Yellow	Purple	Blue	Orange	Red	Green

3.4. Procedure

The children were taken on the experiment route one by one. The tester informed the child about the test. The tester told the child:

> *"I am going to be leading you on a walk in this building today. On this walk you have to look around. Try to pay attention to some details in the building. This is our starting point. When we get to the end of the walk, I will lead us back to here (the main entrance of the building). Then I will ask you to show me the end point of the route with your finger. Do you have any questions? This is our starting point, so let's go!".*

The child was first escorted on the route and s/he was passed by gray or different colored boxes according to the experiment sets. At the end of this route, the child was returned to the starting point X (the main entrance of the building), they were taken outside of the building from the main entrance and they were asked to perform pointing task one by one. They were asked to show the location of the end point Y of the route with their fingers, while they were facing the main entrance of the building from the outside. Thus, they used the technique of an index finger while they were stretching their arm, turning their whole body towards the pointed direction. The answers were analyzed for understanding children's feeling of direction.

4. FINDINGS

Statistical Package for the Social Sciences (SPSS) 12.0 was used to analyze the data. The accuracy in pointing task of the three sample groups (three experiment sets that are set 1, set 2 and set 3) was assessed by comparing children's performances. Analysis of Variance (ANOVA) was used as the statistical technique as the total variation was being analyzed or divided into meaningful components. When random samples of size *n* are selected from each of *k* populations and the *k* different populations are classified on the basis of a single criterion such as different treatments or groups, One-Way ANOVA is used (Walpole, 1998, p.462-63).

The One-Way ANOVA indicated that there is a significant difference between sample groups in the accuracy of pointing task (F=19,002 , p=,000) (see table 2). In order to determine which one of the sample groups differed from the others, Sheffe type Post Hoc Comparison Test that examines sub-groups formed by various combinations of the sample groups, rather than just pair wise comparisons, was used (Argyrous, 2005). The test pointed out that, set 1 (gray set) showed a significant difference when compared with set 2 and set 3 (colored sets). These statistical analyses verify that color has a significant effect on the performance of children to accurately show the end point. Children from colored sets performed pointing task more accurately than children from gray set.

Table 2. Frequency for pointing task performance with the sample group.

		Experiment Set 1		Experiment Set 2		Experiment Set 3	
POINTING TASK PERFORMANCE		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Inaccurate	26	81,3	8	23,5	9	26,5
	Accurate	6	18,7	26	76,5	25	73,5
	Total	32	100	34	100	34	100

To determine if there is a significant relation between gender and the pointing task performance Chi-Square Analysis Tests were conducted. This statistical technique is generally used to assess whether two or more samples each consisting of frequency data (nominal data) differ significantly from each other (Howitt & Cramer, 1997, p.114). According to the analysis, there is not a significant relationship between gender and pointing task performances. ($\chi2$ =2,196, df=1, p=,138). Both genders performed the task equally accurate (see table 3).

Table 3. Frequency for the effect of gender on pointing task performance.

		GENDER		Total
POINTING TASK PERFORMANCE		Female	Male	
	Inaccurate	23	20	43
	Accurate	22	35	57
Total		45	55	100

4. DISCUSSION AND CONCLUSION

The effect of color application to physical environment was explored with young children's pointing task performances at Ankara University Private High School in Ankara. It was demonstrated that the use of color in school environments can affect children's pointing task performances positively.

Read (2003) showed that color helped children to improve their wayfinding and spatial orientation abilities especially in their school environments. Dalke et al. (2005) supported the idea by indicating that using color in children's environment can provide visual interest that affects the efficiency in navigation by providing visual cues in the building. Prior research generally examined the effects of gender, age, familiarity and different methods of assessments on children pointing task performances (Lehnung et al., 2001; Lehnung et al., 2003), but not the effect of color. There are no studies that focus on the effect of color on pointing task performances. In this study, children's performances on pointing task for gray and different colored experiment sets were compared to understand the role of color. It was found that there is a significant difference between gray and colored sets in the accuracy of pointing task. Children in the colored experiment sets were more accurate in showing the location of the end point when compared with the children in the gray set. Therefore, there is a significant effect of color on pointing task performance. Color seems to be helping children to visualize the environment in their minds and to improve their mental map.

In the study it was assumed that gender has an influence on pointing task performance in a way that boys might outperform girls as suggested by previous studies that males outperformed females in indicating the direction of the destination (Lawton et al., 1996; Cubukcu & Nasar, 2005). There was no gender difference in pointing task performances. Both genders performed equally accurate in the tasks. For future research, this study could be repeated with the addition of different demographics such as age and socio-cultural factors. The differences between these demographics may be more dominant than the gender in the performance of spatial abilities for children. It should also be noted that gender differences may increase with age due to cultural and educational impact on individuals. In line with Lehnung et al. (2003) investigating children's spatial abilities in their natural surroundings is important to find out about their spatial competence, and this study was conducted in children's natural environment. Findings of this study could be useful for school administrators, architects, interior architects and designers to provide better physical environments to children for improving their spatial competence.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

5. REFERENCES

Argyrous G. (2005). *Statistics for research: with a guide to SPSS*. London: SAGE Publications.

Cornell, E.H., Heth, C.D., Kneubuhler, Y. & Sehgal, S. (1996). Serial position effects in children's route reversal errors: Implications for police search operations. *Applied Cognitive Psychology,* 10, 301-326.

Cornell, E.H., Sorenson, A. & Mio, T. (2003). Human sense of direction and wayfinding. *Annals of the Association of American Geographers,* 93 (2), 399-425.

Cornell, E.H. & Hill, K.A. (2004). The problem of lost children. In C. Spencer, & M. Blades (Eds.), *Children and their environments: Learning, using, and designing spaces.* Cambridge, UK: Cambridge University Press.

Cubukcu, E. & Nasar, J.L. (2005). Relation of physical form to spatial knowledge in large-scale virtual environments. *Environment and Behavior,* 37 (3), 397-417.

Dalke, H., Little, J., Niemann, E., Camgöz, N., Steadman, G., Hill, S. & Stott, L. (2005). Color and lighting in hospital design. *Optics & Laser Technology*, 38, 343-365.

Gifford, R. (2002). Environmental attitudes, appraisals, and assessments. In B.C. Victoria (Ed.), *Environmental psychology: Principles and practice.* (pp.56-99). Canada: Optimal Books.

Golledge, R.G. (1999). *Wayfinding behavior: Cognitive mapping and other spatial processes*. London: The Johns Hopkins University Press.

Hard, A. & Sivik, L. (2001). A Theory of colors in combination – A Descriptive model related to the NCS color-order system. *Color Research and Application*, 26 (1), 4-28.

Helvacıoğlu, E. (2007). Colour contribution to children's wayfinding in school environments [dissertation]. Ankara (Turkey): Bilkent University.

Helvacıoğlu, E. & Olguntürk, N. (2011). Color contribution to children's wayfinding in school environments. *Optics and Laser Technology,* 43 (2), 410-419.

Heth, C.D., Cornell, E.H. & Flood, T.L. (2002). Self-ratings of sense of direction and route reversal performance. *Applied Cognitive Psychology,* 16, 309-324.

Higgins, S., Hall, E., Wall, K., Woolner, P. & McCaughey, C. (2005). *The impact of school environments: A Literature review*. London: Design Council.

Hill, K. (1998). *The psychology of lost.* Ottawa, Canada: National SAR Secretariat.

Howitt, D. & Cramer, D. (1997). *A Guide to computing statistics with SPSS for windows*. England: Pearson Education Limited.

Hunt, E. & Waller, D. (1999). *Orientation and wayfinding: A review. (ONR technical report N00014-96-0380).* Arlington, VA: Office of Naval Research.

Ishihara S. (1975). Ishihara's tests for colour-blindness. Japan: Kanehara Medical Publishing Co. Ltd.

Ishikawa, T., Fujiwara, H., Imai, O. & Okabe, A. (2008). Wayfinding with a GPS-based mobile navigation system: A comparison with maps and direct experience. *Journal of Environmental Psychology*, 28, 74-82.

Janzen, G. (2006). Memory for object location and route direction in virtual large-scale space. *The Quarterly Journal of Experimental Psychology*, 59 (3), 493-508.

Lang, J. (1987). *Creating architectural theory: The role of the behavioral sciences in environmental design*. New York : Van Nostrand Reinhold Co.

Lawton, C.A., Charleston, S.I. & Zieles, A.S. (1996). Individual-and gender-related differences in indoor wayfinding. *Environment and Behavior,* 28 (2), 204-219.

Lehnung, M., Haaland, V.O., Pohl, J. and Leplow, B. (2001). Compass-versus finger-pointing tasks: The influence of different methods of assessment on age-related orientation performance in children. *Journal of Environmental Psychology*, 21, 283-289.

Lehnung, M., Leplow, B., Haaland, V.O., Mehdorn, M. & Ferstl, R. (2003). Pointing accuracy in children is dependent on age, sex and experience. *Journal of Environmental Psychology*, 23, 419-425.

Malinowski, J.C. & Gillespie, W.T. (2001). Individual differences in performance on a large-scale, real-world wayfinding task. *Journal of Environmental Psychology,* 21, 73-82.

Maxwell, L.E. & Chmielewski, E.J. (2008). Environmental personalization and elementary school children's self-esteem. *Journal of Environmental Psychology,* 28, 143-153.

Murakoshi, S. & Kawai, M. (2000). Use of knowledge and heuristics for wayfinding in an artificial environment. *Environment and Behavior*, 32 (6), 756-774.

Orr, D.W. (1992). *Ecological literacy: Education and the transition to a postmodern world.* New York: State University of New York Press.

Passini, R. (1984). Wayfinding in Architecture. New York: Van Nostrand Reinhold.

Read, M.A. (2003). Use of color in child care environments: Application of color for wayfinding and space definition in Alabama child care environments. *Early Childhood Education Journal*, 30 (4), 233-239.

Spiers, H.J. & Maquire, E.A. (2008). The dynamic nature of cognition during wayfinding. *Journal of Environmental Psychology*, 28, 232-249.

Smith, D. (2003). Environmental coloration and/or the design process. *Color Research and Application*, 28 (5), 360-365.

Thompson, S. (2003). Color in education. *School Planning and Management,* Retrieved September 27, 2006, from http://www.peterli.com/archive/spm/551.shtm

Ünal, B. & Akın, E. (2017). Geçici afet konutlarının kullanıcı açısından değerlendirilmesi: Van depremi konteyner konutları. Online Journal of Art and Design, 5 (4), 71-88.

Wilson, R. (1997). Environmental education: A Sense of place. *Early Childhood Education Journal*, *24* (3), 191-19.